APPENDIX C

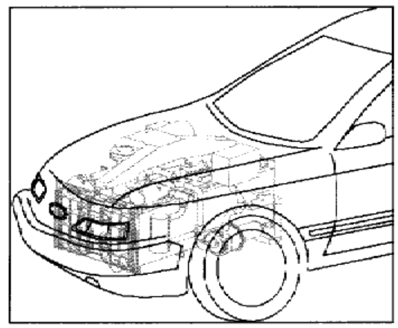
U.S. DEPARTMENT OF ENERGY R&D ON FUEL CELLS FOR TRANSPORTATION: ABSTRACTS OF CURRENT PROGRAMS

Integrated System Development

Direct-Hydrogen-Fueled Proton-Exchange-Membrane Fuel Cell System for Transportation Applications

Contractor: Ford Motor Company — *Dearborn, MI*
Point of Contact: Bradford Bates — *(313) 594-7957*

Ford Motor Company has been conducting research and development of alternative power sources and alternative fuels for automotive applications to meet increasingly stringent emission regulations and demand for higher fuel economy. The fuel cell vehicle, if fueled by hydrogen, is a true Zero Emission Vehicle whose range is limited only by the amount of fuel carried onboard. For these reasons, the fuel cell engine is an attractive alternative with the potential to replace the internal combustion engine. Ford began fuel cell development activities in July 1994. In addition to fuel cell development by five subcontractors in Phase I, hydrogen infrastructure issues were addressed by another team of subcontractors. In Phase II, two of the fuel cell subcontractors were selected to continue development of integrated 50-kW net dc power PEM fuel cell systems fueled by hydrogen. The technical targets for the fuel cell power system are 2.7 kg/kW net power and 0.25 mg Pt/cm^2 active area.



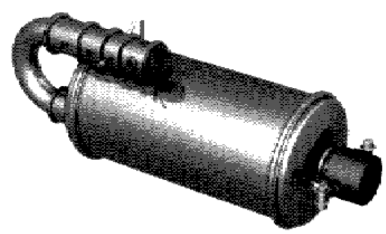
Subcontractors:
Directed Technologies, Arlington, VA
Plug Power, L.L.C., Latham, NY
International Fuel Cells Corp., South Windsor, CT

Deliverable: *50-kW (net) integrated, hydrogen-fueled PEM fuel cell power system*

Research and Development of a PEM Fuel Cell System for Transportation Applications

Contractor: General Motors Corporation — *Detroit, MI*
Point of Contact: Swathy Swathirajan — *(810) 986-0702*

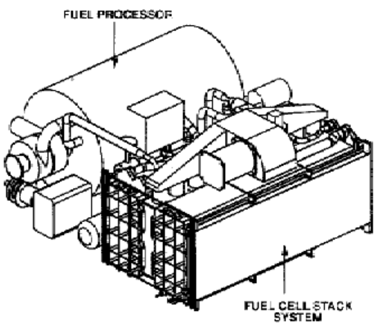
General Motors is working on the development of a 30 kW (net) PEM fuel cell system running on methanol reformate. Methanol can be sold and stored in a manner familiar to automobile owners, has a higher energy density than hydrogen, and can be reformed into hydrogen onboard the vehicle. Successful operation of this fuel cell system requires it to be built within the constraints of automotive system needs and operational conditions. The General Motors R&D program is focused on those areas in most need of technological innovation, including the development of the fuel processor system, the PEM fuel cell stack, and the development of the system integration and control subsystems. The project also includes powertrain component and vehicle trade-off analysis.



GM Combustion Heated 30-kW System Reformer

Subcontractors:
Delphi Engine and Energy Management Systems, Rochester, NY
Delphi Harrison, Lockport, NY
Delphi Packard, Warren, OH
Delco Electronics, Kokomo, IN

Deliverable: *Stand-alone 30-kw (net) fuel cell power system operating on methanol reformate*



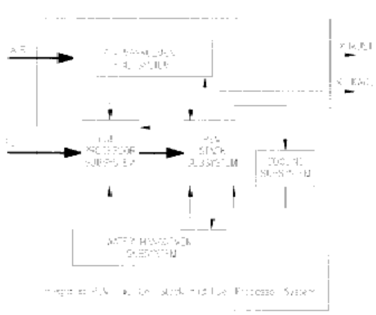
Integrated Power System for Transportation

Contractor: International Fuel Cells Corp. South Windsor, CT
Point of Contact: Alfred P. Meyer (860) 727-2214

The fuel cell has been proven to be an attractive prime mover for automotive applications because it can be the cornerstone of a sustainable energy program in the United States. It can provide the highly efficient conversion of fuel to PNGV mileage goals, and can do so with either zero-emissions or the lowest emissions possible when using conventional motor fuel. A major challenge however in introducing the fuel cell into automotive service quickly is to find a way to make it compatible with gasoline or diesel fuel, the traditional automotive fuels, and to reduce its cost, weight and volume to competitive automotive targets. Recent development work in compact ambient pressure fuel cells and fuel-flexible fuel processors has produced great strides in moving these technologies toward satisfying automotive goals. This program will bring these technologies together into a demonstrator fuel cell power plant which is on the path toward meeting all automotive goals both near term, using current infrastructure fuels, and long term using renewable fuels.

Subcontractors:
Arthur D. Little, Cambridge, MA
Texaco, Beacon, NY

Deliverable: 50-kW (net) PEM stand alone power system



Integrated Power System for Transportation

Contractor: Plug Power, L.C.C., Latham, NY
Point of Contact: Dr. William D. Ernst (518) 785-2859

Development of a fuel cell power system operating on common transportation fuels for automotive use will require both technical and cost improvements in all major subsystems, and their integration into a functional system. We will make advances in PEM stack, flexible fuel processor, and balance-of-plant technologies to address size, weight, manufacturing cost, reliability, durability and operational issues. The 50-kW net system targets for operation on reformed gasoline fuel include demonstration of greater than 40 percent efficiency at partial power, achieving 250 watts per liter power density, and durability of 2000 hours. Beginning in 1997, we will perform an internal integration of a brassboard stack and fuel processor system to establish preliminary 50-kW system definition.

Subcontractors:
Arthur D. Little, Cambridge, MA
Masco Corp., Taylor, MI
Texaco, Beacon, NY

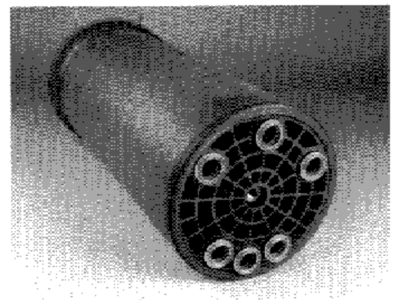
Deliverable: Fully integrated 50-kW PEM fuel cell power system

Fuel Cell Stack System

R&D of a 50 kW, High Efficiency, High Power Density, CO-Tolerant PEM Fuel Cell Stack System

Contractor: AlliedSignal-AES, *Torrance, CA*
Point of Contact: Tim Rehg *(310) 512-2281*

The PEM fuel cell power plant holds considerable potential as a cleaner, more efficient alternative to the automobile internal combustion engine. These benefits will be realized when PEMFC technology advancements warrant consumer acceptance—comparable power plant performance to today's automobile at a comparable price and utility. We will develop a 50-kW (net) PEM fuel cell power system that will operate on reformed hydrogen derived from liquid infrastructure fuels such as methanol and gasoline. The PEMFC power system will demonstrate the capability to achieve: a fuel efficiency of 40% at 12.5 kW (cruising conditions), a compact size (0.35 kW/L) and weight (0.35 kW/kg), and a high volume production cost of $100/kW. This effort will build on our existing low cost PEMFC stack technology amenable to high volume manufacturing and suitable for automotive applications.



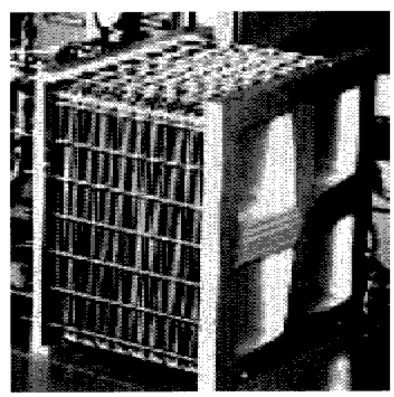
Subcontractors:
AlliedSignal-ASRT, Des Plaines, IL and Morristown, NJ
AlliedSignal Automotive, Southfield, MI

Deliverable: 50-kW (net) PEM fuel cell stack system

Development of Composite Bipolar Collector Plates and Advanced Reformate Fuel Cell Stack Design for Transportation Applications

Contractor: Energy Partners, Inc. *West Palm Beach, FL*
Point of Contact: Rhett Ross *(561) 688-0500*

The goal of this program is to develop advanced, low cost proton-exchange-membrane (PEM) fuel cell stack and system designs for operation on reformate and use in vehicle power systems. Energy Partners will attain this goal by conducting studies and experiments aimed towards improvement of the following three areas: (1) Bipolar collector plates (graphite, binding materials, flow field design, molding, heating and cooling techniques, economic analysis, and manufacturing methods for mass production), (2) Stack design to operate on reformate (incorporation of the new collector plates, selection of suitable MEAs, and architecture of stack hardware for implementation in automotive applications), and (3) System design and integration.



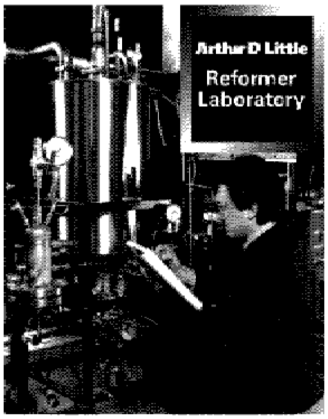
This R&D project will be completed in two phases. Phase I, with a duration of eighteen months, will conclude with the design, fabrication and testing of a proof of concept 10-cell stack operating on reformate as well as the design of an optimized system meeting automotive requirements and able to operate on reformate. Phase II, with a duration of six months, will conclude with the delivery of a 50 kW net fuel cell power system, excluding the fuel reformer, for automotive use.

Deliverable: 50-kW (net) PEM fuel cell stack system

Fuel Processor

Advanced Fuel Processor Development

Contractor: Arthur D. Little, Inc. — *Cambridge, MA*
Point of Contact: William L. Mitchell — *(617) 498-6149*



ADL will design, build, and test a 50 kW_e fuel reformer capable of processing gasoline as well as alternative fuels such as ethanol. Major technical issues to be addressed in this program include:

- Advanced catalysts
- CO clean-up
- Transient controls, and
- Reformer start-up/shut-down time

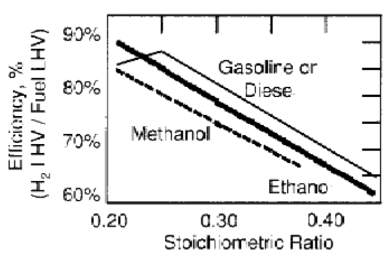
As an extension of the integrated fuel processor, ADL will develop and test an advanced 50 kW_e PROX device based on proprietary catalyst technology. Reformate purity when operating on gasoline and ethanol will be a major focus of the fuel processor development. ADL will support both the International Fuel Cells and Plug Power programs on the development of 50 kW integrated PEM fuel cell power systems.

Subcontractors:
Universal Oil Products, Des Plaines, IL
Texaco, Beacon, NY
Modine Manufacturing Co., Racine, WI

Deliverables: Trade-off design study
Two 50kW fuel processor systems; one each to International Fuel Cells, Inc. and Plug Power, L.L.C.

Fuel Flexible, UOB™ Fuel Processor System Development

Contractor: Hydrogen Burner Technology — *Long Beach, CA*
Point of Contact: Richard R. Woods — *(562) 597-2442*



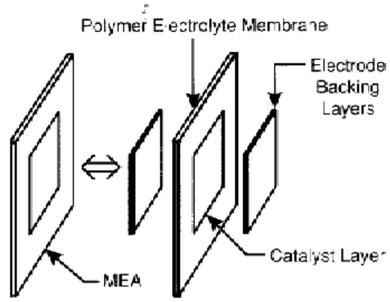
To increase the fuel efficiency and decrease the air emissions from cars and other vehicles, automotive manufacturers are interested in fuel cells as a replacement for conventional engines. Fuel cells need hydrogen as a fuel, and our fuel-flexible processor enables these vehicles to use conventional gasoline today and renewable fuels in the future. In 1998, we will address component designs and integration issues focused toward higher fuel conversion efficiency in smaller compact hardware, and process modifications directed toward improved product gas purity for improved fuel cell life and performance.

Deliverables: 50 kW integrated fuel flexible fuel processor subsystem
50 kW humidified low temperature shift reactor

PEM Stack Components/Materials

High Performance, Low Cost Membrane Electrode Assemblies for PEM Fuel Cells

Contractor: 3M Co. *St. Paul, MN*
Point of Contact: Dr. Mark Debe *(612) 736-9563*



Key technological advances in the development of polymer electrolyte fuel cells have been sufficient in the past 5-10 years that commercialization appears feasible from this standpoint. High cost remains a significant barrier to commercialization in the transportation markets. High performance and high reliability, but at a sufficiently low cost to be competitive with alternative and existing motive power sources is required. 3M shall investigate novel five layer membrane electrode assemblies for polymer electrolyte membrane fuel cells based on a fundamentally new, nanostructured thin film catalyst and support system. The effort is directed towards demonstrating a continuous low cost process for high volume manufacture of high performance ultra-low loading catalyst electrodes in commercial membranes, obtaining new anode catalyst compositions and structures for optimized CO tolerance, and development of a continuously produced, low cost carbon electrode backing media with properties optimized for use in the MEA.

Subcontractors:
International Fuel Cells, Corp., South Windsor, CT
Energy Partners, Inc., West Palm Beach, FL

Deliverable: Advanced large-area MEAs for performance evaluation on reformate/air by stack development subcontractors

Layered Bipolar Plates for PEM Fuel Cell Stacks

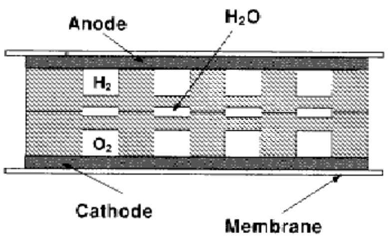
Contractor: ElectroChem, Inc. *Woburn, MA*
Point of Contact: Dr. Radha Jalan *(617) 938-5300*

Cost is the principal factor inhibiting the widespread use of fuel cells as electrical power sources. The most expensive component in the manufacture of lower cost PEM fuel cells are the solid graphite bipolar separator plates. Our development program will examine a new approach to separator plate design and manufacturing which incorporates several commonly available materials into a layered structure which is resistive to corrosion, impermeable, has high electrical conductivity and much lower cost. Our program plan also incorporates a step-wise approach which can take advantage of these lower cost plate designs even at modest manufacturing volumes.

Deliverable: 6" by 6" prototype PEM stack with layered bipolar plates

Development of a $10/kW Bipolar Separator Plate

Contractor: Institute of Gas Technology *Des Plaines, IL*
Point of Contact: Leonard G. Marianowski *(847) 768-0559*



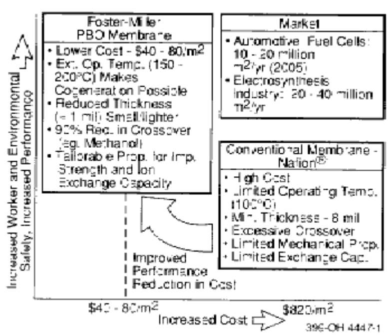
IGT is developing a low cost molded separator plate which will provide a major reduction in the cost of a PEMFC stack. Thermal as well as water management is possible by the choice of molding parameters and materials. Superior Graphite Company will assist us as an expert in the selection of various graphitic materials to optimize the electric properties of the finished product. Plates can be molded to any configuration with varying degrees of porosity for in-situ humidification and water removal. We will test various composites using additional resins and graphite types to enhance conductivity and corrosion resistance. Commercial scale size plates will be molded for in-cell testing of performance and endurance of the plates. Stimsonite Corporation will produce high precision molding dies using their proprietary technology for the program. A commercial manufacturing line will be designed and recommended for the rapid production of these plates using their technology.

Subcontractors:
Superior Graphite Co., Chicago, IL
Stimsonite Corp., Niles, IL

Deliverable: *Performance tested, full-size (230 cm^2), molded graphite composite bipolar plates*

Low-Cost, High Temperature, Solid Polymer Electrolyte Membrane for Fuel Cells

Contractor: Foster-Miller, Inc. *Waltham, MA*
Point of Contact: Dr. Robert F. Kovar *(617) 684-4114*



The market for fuel cell membranes is estimated to be 30 - 60M m^2/yr by 2005. In this program, Foster-Miller will develop a new low-cost, high temperature solid polymer electrolyte membrane. The Foster-Miller membrane:

- will be lower in cost
- will be able to endure extended operating temperatures permitting cogeneration
- will permit reduced membrane thickness leading to smaller and lighter weight fuel cells
- will exhibit a 90% reduction in fuel crossover (e.g., MeOH)
- will exhibit improved strength and ion exchange capacity

Subcontractor:
Giner, Inc., Waltham, MA

Deliverable: *Full-size (320 cm^2) MEAs performance tested in a 1 kW stack*

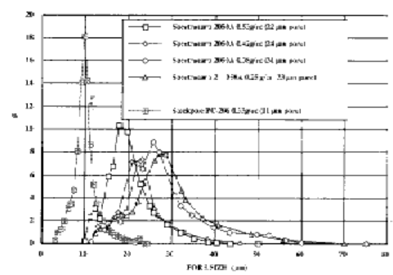
Development and Optimization of Porous Carbon Papers Suitable for Gas Diffusion Electrodes

Contractor: Spectracorp Ltd. — *Lawrence, MA*

Point of Contact: Gerald J. Fleming — *(508) 682-1232*

Much of the R&D effort in fuel cells has been placed upon electrochemical aspects of the cell such as catalysts, electrolytes and membranes. We intend to correlate the performance of the porous carbon fiber based gas diffusion electrodes to the physical structure of the paper as evidenced in pore size and distribution, density, conductivity, and thickness. A model will be developed based on these findings, and we will subsequently optimize the paper structure for fuel cell applications.

PORE SIZE DISTRIBUTION FOR SEVERAL POROUS CARBON MATERIALS



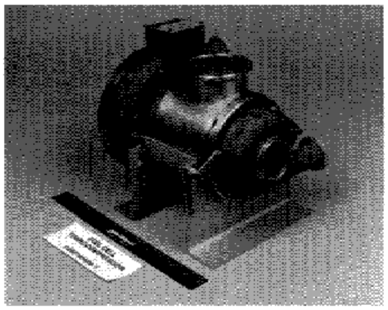
Subcontractor:
Physical Science, Inc., Andover, MA

Deliverable: Optimized porous carbon paper performance tested in 160 cm^2 membrane electrode assemblies

Air Management Systems

Turbocompressor for PEM Fuel Cells

Contractor: AlliedSignal Inc. - AES — *Torrance, CA*
Point of Contract: Mark K. Gee — *(310) 512-3606*

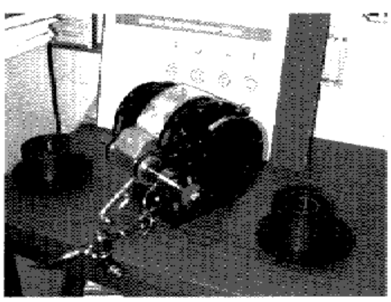


PEM fuel cell systems for transportation require a compact, low weight, and efficient air compressor that provides a clean air flow to the fuel cell stack. The AlliedSignal turbocompressor is being developed to address these requirements. In 1997, a turbocompressor was designed, assembled, and tested. In 1998, AlliedSignal will investigate methods of efficiently extending the flow operating range, particularly at low flows. This turbocompressor should enable the PEM fuel cell to meet system efficiency goals at low power levels. Also included is durability testing and the layout and design of a production automotive turbocompressor.

Deliverable: *Turbocompressor optimized for an automotive fuel cell*

Development of Second Generation Scroll Compressor Expander Module for PEM Fuel Cell Pressurization

Contractor: Arthur D. Little, Inc. — *Cambridge, MA*
Point of Contact: John T. Dieckmann — *(617) 498-5818*



Automotive fuel cell systems will require a compact, reliable, and efficient compressor/expander module (CEM). Air must be supplied at the elevated pressure levels of anticipated fuel cell systems, and recovery of energy from the pressurized exhaust gases in an expander will be necessary to achieve acceptable system efficiency. A first-generation scroll CEM was developed, constructed, and demonstrated in a fully-instrumented test stand in 1997. Development for a second-generation scroll CEM will begin in late 1997. The improvement potential for the scroll technology will first be thoroughly investigated and the CEM design will then be modified to reduce size and weight, improve performance and efficiency, increase durability, reduce noise, and incorporate water injection into the compressor. A second-generation prototype incorporating these improvements will be built and tested in 1998. The program will include testing of a fully integrated fuel cell system including the scroll CEM.

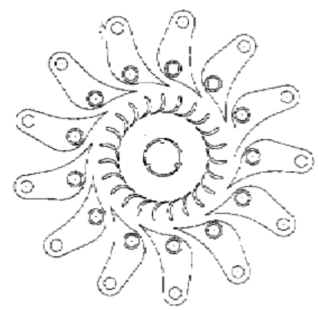
Subcontractors:
Scroll Corporation, Carlisle, MA
Acentech Inc., Cambridge, MA

Deliverable: *Second generation CEM performance tested in integrated PEM fuel cell system*

Electrically Boosted Gas Bearing Turbocompressor for Fuel Cells

Contractor: Meruit Inc. — *Santa Monica, CA*
Point of Contact: G. Fonda-Bonardi — *(310) 453-3259*

Turbocompressors used to feed air to fuel cells and driven by the fuel cell exhaust require minimal internal (bearing) losses and the absence of oil contamination of the feed air. Gas bearings solve both problems at once and are a clear choice if they can be made (1) at low cost, (2) long lived, and (3) rugged enough to withstand shocks inherent in vehicular use. Meruit has built and tested a journal (radial) that meets all three basic requirements. We will (1) adapt the principles of the journal bearing to a companion thrust bearing; (2) test the combined journal and thrust bearings in conditions similar to those expected in fuel cells; (3) build and test a prototype turbocompressor using the combined radial and thrust gas bearing and optimized for a specific fuel cell to be selected; and (4) deliver two prototypes, one for independent testing, and the other for integration into the selected fuel cell air system.



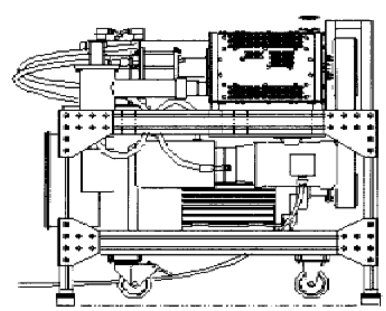
<u>*Subcontractor:*</u>
Test Devices, Inc., Hudson, MA

<u>*Deliverables*</u>: *Two gas bearing turbocompressors for testing and evaluation*

Variable Displacement Compressor Development

Contractor: Vairex Corporation — *Boulder, CO*
Point of Contact: Jeremiah Cronin — *(303) 444-4556*

The Vairex effort builds upon the successfully demonstrated variable displacement technology applied to both a compressor and expander. The system achieved a 3.2 constant pressure ratio while varying its mass delivery over a 10:1 turndown. This development phase will raise the mass flow by 50% through improvements in air flow, heat and water management, kinematic control and materials. Performance characteristics will be generated and provided to potential fuel cell air system users.



<u>*Deliverable*</u>: *Performance tested variable displacement compressor*

Hydrogen Storage[1]

High-Pressure Conformable Hydrogen Storage for Fuel Cell Vehicles

Contractor: Thiokol Corporation — *Brigham City, UT*
Point of Contact: Dr. Richard K. Kunz — *(801) 863-8799*

Vehicle range is a critical issue confronting consumer acceptance of alternate fuel vehicles. Major factors influencing range are vehicle energy efficiency, energy density of the fuel, and the quantity of fuel on-board. However, the energy density of gaseous hydrogen compressed to 5000 psi is less than 10% that of gasoline. Therefore, to achieve comparable range, a significantly larger volume of on-board high pressure hydrogen storage is required. Thiokol will address the on-board storage of hydrogen for fuel cell-powered vehicles using their conformable tank technology for high pressure storage. Non-cylindrical conformable tanks offer the capability for more efficient utilization of available vehicle storage space, providing acceptable range without sacrificing cargo room. On this program Thiokol will demonstrate, through fabrication of full scale tanks and environmental testing, full scale conformable high pressure hydrogen storage tanks.

Subcontractor:
Aerotech Corp., Ramsey, NJ

Deliverable: Strength and environmental testing of full-scale, conformable high-pressure hydrogen storage tanks

Advanced Chemical Hydride Hydrogen Generation/Storage System for PEM Fuel Cell Vehicles

Contractor: Thermo Power Corp., Tecogen Div. — *Waltham, MA*
Point of Contact: Dr. Ronald Breault — *(617) 622-1046*

To supply high purity hydrogen for fuel cell powered vehicles, Thermo Power Corporation is proposing the use of a chemical hydride/organic slurry as the hydrogen carrier and storage medium. At the point of use, high purity hydrogen will be produced by reacting the hydride slurry with water. In addition, Thermo Power has conceived the paths for recovery and regeneration of the spent hydride. Not only will the technology be capable of meeting DOE's hydrogen storage goals, but the entire process will be economically favorable and environmentally friendly. The program will focus on the development of a prototype 50 kW electric power equivalent hydrogen supply system. The program covers a 30 month period. During the first 15 months, the work will be directed towards optimizing the proposed process utilizing a laboratory-scale reactor. In the second 15 month phase, the design, fabrication and testing of a prototype system encompassing all the major components will be completed.

Deliverable: 50 kW electric power equivalent hydrogen supply system

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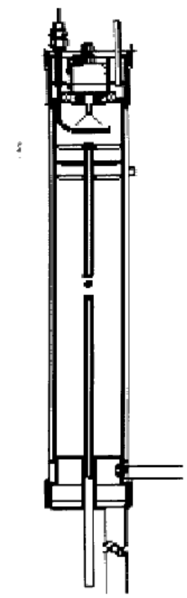
[1] Funding for these projects is provided by the U.S. DOE Hydrogen Program. For further information contact Sigmund Gronich, Program Manager, U.S. Department of Energy, 1000 Independence Ave., SW, Washington, DC 20585. Phone: (202) 586-1623; Fax: (202) 586-5127.

National Laboratory R&D

Catalytic Partial-Oxidation Reformer for Gasoline

Argonne National Laboratory — *Argonne, IL*
Point of Contact: Romesh Kumar — *(630) 252-4342*



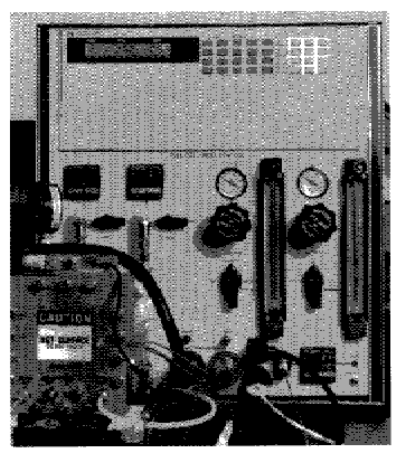
For use with automotive fuel cell power systems, on-board fuels other than hydrogen must first be converted to hydrogen using a reformer. We are developing a catalytic partial-oxidation reformer to convert gasoline, as well as alternative fuels (methanol, ethanol, natural gas, and other hydrocarbons) to a hydrogen-rich fuel gas. This compact, light-weight reformer requires no fuel vaporization or preheating of the fuel or air, is designed for rapid start-up, and offers excellent dynamic response. We have developed a unique family of bifunctional catalysts that makes it feasible to reform a variety of transportation fuels at temperatures of 750°C or less. In FY 1997, we demonstrated that the Argonne catalysts can convert various fuels, including regular and premium gasolines with high efficiency (~80% for premium gasoline) and hydrogen selectivity (over 90% from premium gasoline). In FY 1998, we will test these and other improved catalysts in a 10-kW (nominal) prototype reformer. We will also integrate this reformer with water-gas shift and CO clean-up reactors, and verify the quality of the resulting fuel gas by operating a polymer electrolyte fuel cell on the reformate from gasoline, as well as other fuels of interest for transportation applications.

Deliverable: *Demonstrate operation of catalytic partial oxidation reformer operating on gasoline integrated with a PEMFC*

PEM Fuel Cell and CO Cleanup R&D

Los Alamos National Laboratory — *Los Alamos, NM*
Points of Contact: Shimshon Gottesfeld — *(505) 667-6832*
Nick Vanderborgh — *(505) 667-6651*

This effort is primarily focused on: CO tolerance of PEMFCs, direct methanol fuel cells, innovative PEMFC components and systems, and development of a preferential oxidation (Prox) subsystem for CO cleanup. The CO produced when hydrocarbons are reformed readily poisons the PEM anode electrocatalysts typically used. On the fuel cell side, we are developing operating schemes, electrocatalysts, and electrode structures to alleviate the poisoning effect. On the fuel processing side, we are continuing the development of a Prox reactor to reduce the CO in reformed fuels to acceptable levels.



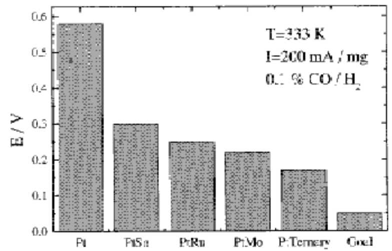
Fuel Cell Test Station

A simple fuel cell system using a liquid fuel is the direct electro-oxidation of methanol. The primary challenges are poor electro-kinetics and fuel loss by cross-over though the MEA. Having demonstrated schemes with minimal crossover, we are working to attain long-term stability, improve power density, and reduce electrocatalyst loading. New concepts are also being developed to improve the commercial viability of PEMFC systems. We are working to scaleup a simple PEM system with less than 3% parasitic losses and innovative composite bipolar plate materials to transportation relevant sizes, and to improve the manufacturability and cost of the bipolar plate materials.

Deliverable: *Design, fabrication, and test of a 50 kW Prox subsystem*

Electrode Kinetics and Electrocatalysis

Lawrence Berkeley National Laboratory — *Berkeley, CA*
Point of Contact: Philip N. Ross, Jr. — *(510) 486-6226*

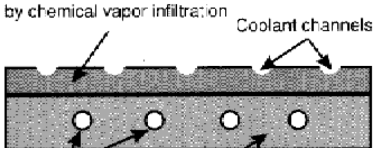


LBNL is working to determine the kinetics and mechanism of the electrode reactions in low temperature fuel cells and provide the intellectual foundation for the development of new catalysts. Our approach, which is unique to this laboratory, is to use UHV methods of surface preparation and surface analysis to form well-characterized electrode surfaces, to study the kinetics of fuel cell electrode reactions using modern electroanalytical methods on these surfaces, and to use these surfaces to study the mechanisms of the reactions using state-of-the art *in-situ* spectroscopies. We have established the general trends in the electrooxidation of C_1 molecules (methanol, formic acid, formaldehyde, and carbon monoxide) on Pt_{1-X} M_X alloy surfaces with varying M and x. Progress is being made towards the development of a CO-tolerant anode catalyst. Both Pt-Ru and Pt-Mo alloy catalysts, available commercially, provide CO-tolerance at very low levels of CO, e.g. < 100 ppm CO. A truly new type of catalyst will be required to provide CO-tolerance at levels on the order of 0.1 % CO.

Deliverable: Anode catalyst with a CO tolerance on the order of 0.1%.

Carbon Fiber/CVI Bipolar Plate[2]

Oak Ridge National Laboratory — *Oak Ridge, TN*
Point of Contact: T. M. Besmann — *(423) 574-6852*



We are developing a slurry molded carbon fiber material with a carbon chemical vapor infiltrated (CVI) sealed surface as a bipolar plate. The fibrous component preform for the bipolar plate is produced by slurry molding techniques using carbon fibers and particulates. A two-step vacuum molding process first produces a high density, fine porosity surface followed by molding of the lower density, porous region. The high density surface of the preform will be sealed using a CVI technique in which carbon is deposited on the near-surface fibers to make the surface hermetic. The infiltrated carbon provides both an impermeable surface as well as the necessary electrical conductivity so that power can be obtained from the cell. Specimens are being provided to Los Alamos National Laboratory for permeability and electrical resistivity measurements. One or more potential carbon fiber component manufacturers are being contacted with regard to the manufacturability of the proposed bipolar plate.

Deliverable: Process for manufacturing molded carbon bipolar plates

[2] Funding for this project provided by the U.S. DOE Lightweight Vehicle Materials Program, Office of Advanced Automotive Technologies. For further information, contact Joe Carpenter, Acting Program Manager, U.S. Department of Energy, 1000 Independence Ave., SW, Washington, DC 20585. Phone (202) 586-1022; Fax (202) 586-9811.

Microchannel Fuel Processor Development

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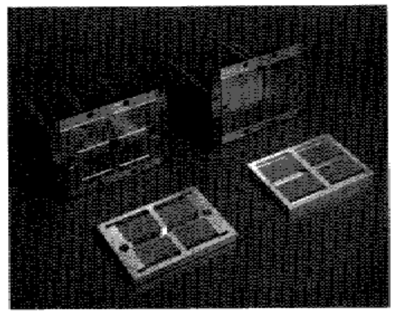
The development of an onboard fuel processing system, to produce hydrogen gas from liquid hydrocarbons for fuel cell use, presents a number of technical challenges, including process miniaturization and thermal energy integration. During 1997, we demonstrated an extremely compact fuel vaporizer (1" x 3" x 4"), which captures and recycles energy from unused hydrogen in the fuel cell waste gas, by catalytically reacting it with air, and then routing the stream through microchannel heat exchangers within which methanol is evaporated. Pictured at right, this vaporizer consists of four reactor cells and four heat exchanger cells, and is able to vaporize 400 mL/min of methanol. Two units operating in parallel can provide sufficient vapor fuel stream for a 50 kW_e automotive system. Work planned for 1998 includes additional testing of the vaporizer over extended periods, and demonstration of other process reactors for the automotive fuel cell system (e.g., partial oxidation, water-gas-shift, and preferential oxidation reactors) using engineered microstructures.



Deliverable: *Demonstration of an integrated fuel processing system*